Local earthquake tomography in the Eastern and eastern Southern Alps using Swath D data

Christian Haberland[1]

1. GFZ Potsdam, Germany

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The AlpArray collaborative project was a multinational, European initiative focused on the Alpine-Apennine-Carpathian-Dinarid orogenic system, established to improve our understanding of the Alpine orogeny and geology (see e.g., Hetényi et al., 2018). The backbone of this project was the large AlpArray seismic network (AASN) with more than 600 stations deployed in the greater Alpine area (Hetényi et al., 2018).

In addition to this regional network, the temporary Swath D network was installed as part of the 4D-MB project (Heit et al., 2021). This network included 163 stations that were operated for two years. It was located along the tip of the eastern Adriatic indenter and covered for example part of the proposed Moho gap in the Eastern Alps and the slab gap between Central and Eastern Alps. With an average station spacing of 15 km it was significantly denser than the AASN (average spacing of 52 km) and thus enabled for high-resolution imaging of key areas within the Alpine region, particularly on the crustal and upper mantle scale as well as the precise location of local earthquakes. The high density of the Swath D network was particularly important for high resolution imaging considering that there is only a moderate rate of seismicity in the study region.

The Swath D data was therefore ideal to be used in local earthquake tomography (LET), which is a mature, powerful inversion method to provide high-resolution images of the subsurface especially on the crustal scale.

In a first step earthquake arrival times of P- and S-waves (observed at Swath D and selected AASN stations) were picked and inverted for velocity models, station corrections, earthquake hypocenters and origin times (Jozi Najafabadi et al., 2021). In this way the seismicity (mainly in the upper 20 km) of the Alpine frontal thrust, e.g., the Friuli-Venetia region, the Giudicarie–Lessini and Schio-Vicenza domains, the Austroalpine nappes, and the Inntal area was revealed.

In a second step the arrival time data were inverted for the 3-D velocity structure (Jozi Najafabadi et al., 2022). Due to the irregular distribution of earthquakes, extensive resolution testing was necessary. The predominantly shallow earthquakes still pose a challenge for the inversion, particularly in terms of resolution of the lower crust and upper mantle. Nevertheless, the derived P-wave velocity model revealed a highly heterogeneous crustal structure in the target area with prominent intracrustal anomalies, Moho topography and a thickened lower crust South of the Periadriatic fault. The models were intensly used for further detailed geological and geophysical investigations (e.g., Verwater et al., 2021).

In a third step the distribution of seismic attenuation of P-waves (1/Qp) was calculated (attenuation tomography). Focussing on the upper crust, several distinct anomalies can be observed. The highest attenuation (lowest QP) anomaly is found in the Friuli-Venetian region which is also characterized by low VP and increased VP/VS. This anomaly may be related to a high fault and fracture density and the presence of fluid-filled sediments of the Venetian-Friuli basin along the eastern part of the Southern Alpine deformation front.

Recently, attempts to obtain vp and vs models from LET have been extended to the greater Alpine region (e.g. Braszus et al., 2023).

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